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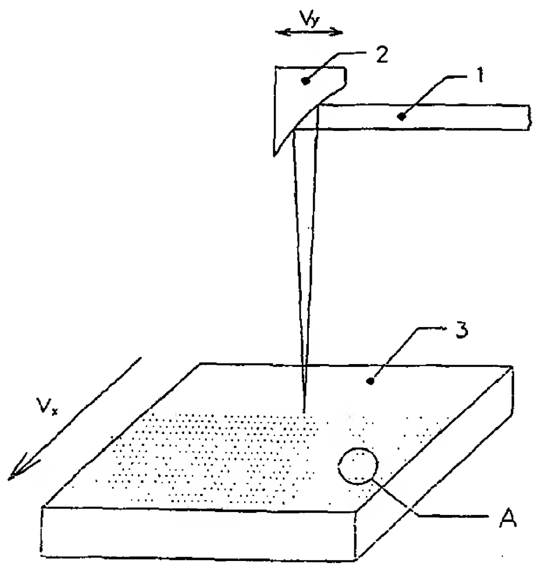
(54) **REVETEMENT DE SOL ANTIDERAPANT ET SON PROCEDE DE PRODUCTION**

(54) **NON-SLIP FLOOR COVERING AND PROCESS FOR PRODUCING IT**



(57) L'invention concerne un revêtement de sol antidérapant, constitué notamment de matériaux minéraux, tels que de la pierre, du granit ou de la céramique. L'invention concerne également un procédé de production de revêtements de sol antidérapants de ce type. Selon l'invention, la surface dudit revêtement de sol est également antidérepante par le fait que des creux (microcratères à effet ventouse) y sont répartis de manière statistique. Selon l'invention, ces microcratères à effet ventouse sont obtenus par l'action ciblée et définie d'impulsions laser.

(57) The invention relates to a non-slip floor covering, especially of mineral materials, e.g. stone, granite or ceramic, and a process for producing it. According to the invention, the surface of the floor covering is additionally non-slip in that depressions (micro-craters with a suction effect) are statistically distributed over it. Said micro-craters with suction effect are obtained by the invention by the targeted and defined action of laser pulses.

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(54) Title: NON-SLIP FLOOR COVERING AND PROCESS FOR PRODUCING IT

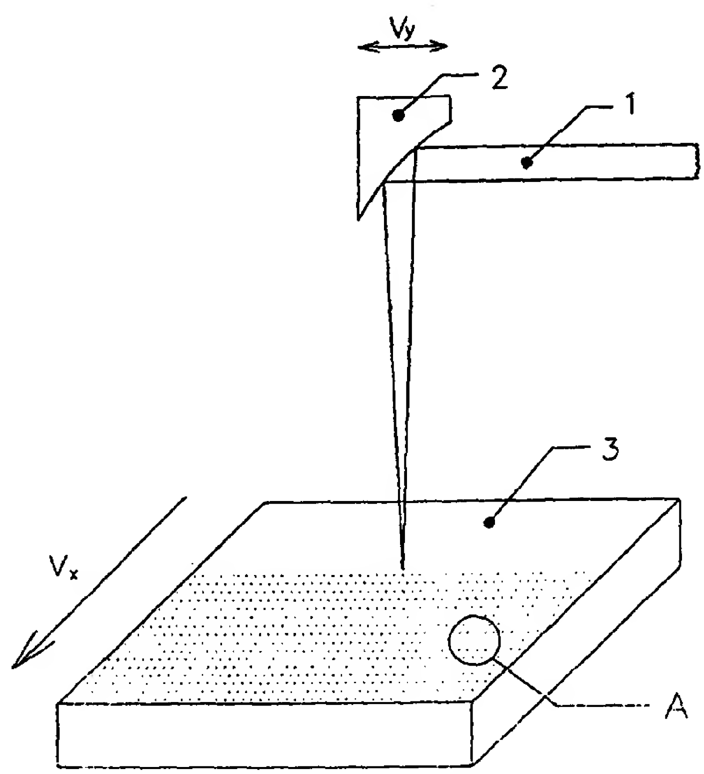
(54) Bezeichnung: RUTSCHFESTER FUSSBODENBELAG UND VERFAHREN ZU SEINER HERSTELLUNG

(57) Abstract

The invention relates to a non-slip floor covering, especially of mineral materials, e.g. stone, granite or ceramic, and a process for producing it. According to the invention, the surface of the floor covering is additionally non-slip in that depressions (micro-craters with a suction effect) are statistically distributed over it. Said micro-craters with suction effect are obtained by the invention by the targeted and defined action of laser pulses.

(57) Zusammenfassung

Die Erfindung betrifft einen rutschfesten Fußbodenbelag, insbesondere aus mineralischen Werkstoffen, wie z.B. Stein oder Granit oder Keramik, sowie ein Verfahren zur Herstellung solcher rutschfester Fußbodenbeläge. Erfindungsgemäß ist die Oberfläche des Fußbodenbelages zusätzlich rutschfest, indem auf ihr Vertiefungen (Mikrokrater mit Saugnapfwirkung) statistisch verteilt angeordnet sind. Erhalten werden diese Mikrokrater mit Saugnapfwirkung erfindungsgemäß durch eine gezielte und definierte Einwirkung von Laserimpulsen.



Non-Slip Floor Covering and Process for Producing Same

Description

The invention concerns a non-slip floor covering and a process for producing same. A special field of application for the invention concerns high polished floors, especially of mineral materials such as, for example, stones (e.g. granite), as are often used in public buildings or buildings accessible to the public, or also ceramic.

Slipping is one of the most frequent causes of accidents in Germany. The seriousness of such accidents is most often underestimated. To increase walking safety, shoe soles and floors must be made so as to be slip-resistant. Above all, this is necessary where slip-promoting substances reach the floor. In many areas of public life, but also in the private sector, it is common to use polished, glossy natural stone slabs as representative floor coverings, both in dry and wet areas as well as in common areas (foyer). It is thereby imperative that the slip-resistant properties be brought into harmony with the architectural aesthetics. The slip-resistance is evaluated according to [DIN 51097 - Determining the slip-resistant property, wet barefoot areas - manner of walking - inclined plane and DIN 51130 - Determination of the slip-resistant property - workrooms and work areas with increased danger of slipping - manner of walking - inclined plane] by means of an inclin d plane.

However, there are also measuring instruments for measurement of the intermittent friction co fficient [Fb 701 Comparative study

for measurement of intermittent friction coefficient on floors (publication series of the Federal Institute for Industrial Safety)].

There are various processes for producing or increasing the slip-resistant properties of floors made of natural stone. Their use depends primarily on the fact where the floor covering is to be laid or where it has already been laid (inside area, outside area, degree of pollution to be expected, etc.). The most important processes shall be briefly described in the following.

In sand-blasting, a granular material chosen according to the desired roughness is blown with compressed air onto the surface to be roughened. The more or less hard radiation material results in an irregular roughening and strong matting of the surface [DE 31 39 427].

In scarfing, high-energy combustible gas/oxygen flames are produced with which the surface to be treated is intensely heated for a short time. Due to the effect of the flames, the quartz in the uppermost rock zone is exploded and other rock components are melted; the latter subsequently solidify into a glassy state and adhere loosely to the surface [DE 35 45 064].

Roughening takes place by use of a granulating tool (granulating hammer) which is provided with several, uniformly arranged chisel tips. During a continuous workpiece movement, the granulating hammer strikes the surface at a specific frequency [DE 39 33 843].

Although the described or similar processes which use abrasive agents or chisel-like tools result in increased walking safety, they also, as e.g. surfaces polished less during manufacturing, result in a considerable loss of gloss and thus a decrease in aesthetic value.

The result of coating surfaces to increase slip resistance is that the treated surface is provided with protuberances [DE 33 42 266]. Although this method does not alter the visual properties, it is durable only to a limited degree since w ar cannot be avoided.

The chemical etching of natural stone surfaces with hydrofluoric acid containing substances preferably attacks the feldspar. [information sheet of the Federal Association for Walking Safety, Public Works Division]. The damage is only a few micrometers, the quartz is spared for the most part. The loss of gloss depends on the duration of the action, the change of the overall appearance must be tested on a sample surface. This process is currently the most advantageous for increasing walking safety of <u>polished</u> natural stone floors. However, it is mainly restricted to mineral floor coverings. Chemical composition and concentration must be adapted to the various types of coverings. As a result of long action times as well as exact observance of the concentration, this process cannot be integrated into th manufacturing process of tiles, or only integrated at a very high cost. This process is not easily suitable for plastic coverings. With improper use and disposal of the hydrofluoric acid containing substances, there is an increased danger to the environment and industrial safety.

Thus, it is now the object of the invention to provide a non-slip floor covering whose surface can be highly polished and a proc ss for producing same, which do not have any of the disadvantages of the prior art.

Thus, it is the object of the invention to propose a non-slip floor covering of the aforementioned type in which no curtailments have to be made on the highly polished surfac , despite the non-slip property, and which can be made in a simple and environmentally friendly manner.

In addition, it is the object of the invention to develop a process of the aforementioned type with which the non-slip property is produced right at the factory and not as a subsequent treatment at the installation site of the floor covering, that is simple and environmentally friendly and which retains the visual appearance and aesthetics of the surface of the floor covering in its entirety.

According to the invention, these objects regarding the non-slip floor covering are solved according to one or more of the claims 1 to 8 and with a process according to one or more of the claims 9 to 11.

The non-slip floor covering, especially of mineral materials such as e.g. stone, granite, with a highly polished surface is, according to the invention, also additionally non-slip on its highly polished surface. This is attained thereby that depressions (microcraters) with a suction effect or suction cup effect are located over the highly polished floor covering surface, said depressions preferably being lenticular, sharp-edged, flat, invisible to the human eye and regularly or randomly distributed.

In this case, invisible means that the microcraters are not recognized as such from a certain distance due to the resolving power of the human eye. The resolution threshold is assumed to be about one angular minute for an observer with normal visi n under optimum lighting conditions [Warnecke, H.J.; Dutschke, W.: <u>Fertigungsmeßtechnik, Handbuch für Industrie und Wissenschaft</u>, Springer-Verlag, Berlin, Heidelberg, New York, Tokyo, 1984]. That is that, at a minimum observation distance of 1.5 m (adult person walking upright), a crater having a maximum lateral expansion of 0.44 mm can just be seen. Preferably, these microcraters have a diameter of 0.03 - 0.4 mm and a depth of 0.01 - 0.2 mm. In floor slabs, there are preferably more than 100 (advantageously, there are more than 250 in floor slabs made of

granite) microcraters per cm^2.

This non-slip floor covering of the invention with a highly polished surface is produced by means of pulse laser bombardment. According to the invention, lenticular and sharp-edged microcraters which are invisible to the human eye and exhibit a suction effect, are produced in a regular or random arrangement by the action of laser pulses. The laser beam parameters such as e.g. energy density, pulse duration, etc., are selected in dependency on the material of the floor covering in such a way that the removal of the material for producing the microcraters is essentially accomplished by evaporation.

In the case of treatment of the highly polished surface of a floor covering made of natural stone, such as e.g. granite, the pulse energy is 0.4 mJ to 1.5 mJ, the pulse duration from 50 ns to 250 ns, the work spot diameter from 0.05 mm to 0.2 mm and the distance of the individual microcraters from one another 0.25 to 0.8 mm.

In contrast to the scarfing, roughening and sand-blasting processes, laser structuring is a non-contact finishing of th surface. The structure can be both regular or random and is distinguished by slight damage to the overall surface. Hardness and composition of the material do not play a role. The process is distinguished by a good controllability of the parameters, i.e. density, depth and diameter of the microcraters may be varied as desired. In this way, the slip-resisting action can be more or less strongly pronounced. According to national and international development results, a friction value of $\mu = 0.43$ between shoe or foot sole and floor can currently be considered adequate and thus non-slip [Fb 701 - Comparative study for intermittent measurement of friction coefficient on floors (publication series of the Federal Office for Industrial Safety)]. In any event, this value is attained or exceeded. As a result, an evaluation and classification according to [DIN

51130 - Determining the slip-resistant property - workrooms and work areas with increased danger of slipping - manner of walking - inclined plane, ZH 1/571 - information sheet for floors in workrooms and work areas with danger of slipping and GUV 26.17 - information sheet of the state accident insurance carriers - BAGUV - concerning floor coverings for wet barefoot areas] is possible.

A destruction of the macroscopic appearance of the floor covering surface, e.g. of the rock, can certainly be excluded. That is why the application relates primarily to polished or smooth, glossy surfaces.

The advantage of the laser treatment vis-à-vis the chemical treatment of mineral floor coverings with a hydrofluoric acid containing substance lies therein that it can be integrated directly into the manufacturing of the floor covering, including slabs and natural freestone (walking safety ex factory). That is, the architect or builder can convince himself of the properties prior to laying e.g. a natural stone covering. A subsequent treatment and a change in the visual appearance of the floor associated therewith is not necessary.

The laser treatment is environmentally friendly since no chemical substances are used. The resultant waste products are, with respect to composition, defined substances corresponding to the riginal material which can be drawn off and disposed of without difficulty. The method can be applied to all floor coverings which are not sufficiently non-slip.

The laser structuring is distinguished by a longer durability vis-à-vis existing coating processes for improving the anti-slip effect. Wear is substantially less than with an additional coating which does not have the hardness of the basic stone.

With the invention, a process is realized which eliminat s the

noted disadvantages, which can, moreover, be used for various floor coverings and can be integrated into the manufacturing process thereof.

According to the invention, microcraters with suction effect are produced by the action of laser pulses. The parameters essential for attaining the effect

- diameter of work spot (determines lateral expansion of the suction cups),
- action time and pulse energy (determine depth of the crater and, in connection with the wavelength of the laser, the type of interaction (evaporation/melting) and the
- spacing of the action points (number and arrangement of craters)

can be easily controlled and can thus be adapted to the respective material and the effects to be attained with respect to visual impression and the friction coefficient.

The aforementioned parameters are preferably also controlled in such a way that the material removal is accomplished essentially by evaporation to avoid producing smelting beads and non-sharp edges since the suction effect would otherwise be affected. It should practically be attained to introduce high energy in a very short time, whereby the material dependency is taken into consideration.

Furthermore, form, depth and width should be set in such a way that preferably lenticular or flat depressions are produced whos depth is, at most, half of the maximum lateral expansion whose depth does not exceed half their diameter, so that no permanent dirt adhesion results. Deflection of the laser beam over the surface takes place with known assembly groups (not part of the subject matter of the invention) such as are known, e.g. from the use of las rs for marking or for surface inspection (scanner or

polygonal mirror in association with plane field optics).

The craters can be arranged in a regular or irregular manner, whereby the regular arrangement is advantageous when still higher walking safety is required and the irregular arrangement of the microcraters with suction effect when there is a slighter visual influence on the polished surface.

The process can be improved in that the surface properties (e.g. colour) and/or the local material composition (e.g. by material-specific absorption and/or reflection) are recorded at the point to be treated by means of suitable sensors (e.g. photooptical scanning) and that these signals are used for controlling the laser source (e.g. pulse energy). As a result, the treatment could also be interrupted in surfaces which are worth maintaining from a visual point of view (e.g. specific types of crystals in natural stone).

The solution according to the invention contains a flexible, environmentally friendly process for producing non-slip materials for smooth floor coverings which meet the need and demand (e.g. polished, mineral floor slabs, plastic coverings and the like) while maintaining the visual appearance and representative properties, whereby the required number of preferably lenticular microsuction cups which are not visible to the human eye with the required geometry and distribution over the surface are produced on the surface by the action of pulsed laser radiation. This non-slip material which meets the requirements and demands, including the adaptation to the material, is attained by the targeted variation and/or selection of the laser beam parameters work spot diameter, wavelength, pulse energy, action time and spacing of the microsuction cups. In this case, the parameters should be selected in such a way that the removal action preferably takes place by evaporation of the material at the spot of incidence. The local surface properties can be recorded by suitable sens rs (e.g. the colour of individual components of the

fl or forming the surface and/or the local chemical composition, for example, of crystals in mineral coverings) and this information can be used to control the laser parameters and/or the geometric arrangement of the laser spot of incidence, including recessing partial areas of the surface.

A great advantage of the process of the invention is that it can be integrated into the finishing process of the floor covering without difficulties.

All of the disadvantages of the prior art can be eliminated with the invention.

The floor covering of the invention and the process of the invention are described in the following examples of embodiments.

Figure 1 thereby shows the creation of the microcraters
and
Figure 2 represents the microcraters themselves.

Examples of Embodiments

Requirement:

- floor tiles made of Lausitz granite - polished
- slip-resistant when water acts upon it
- laying in entrance areas of hotels → best possible retention of visual quality

Realization:

- treatment by means of Nd: YAG laser
- energy density 17 J/cm^2, pulse duration 130 ns, focal distance 150 mm
- focusing on surface of workpiece
- relative movement between laser focus and workpiece preferably takes place by a deflection optic in y direction and by further conveyance of the workpiece in x direction
- 1 pulse per crater to be produced
- crater diameter produced d_u0.04 - 0.45 mm
- distance a of the craters in x and y direction 0.5 mm
- depth t produced 0.1 mm

Result:

- friction coefficient ascertained: μ 0.47 (measured with FSC 2000, plastic slider, sliding agent: expanded water)
- loss of gloss: < 11%
- overall visual effect is very slight

List of Reference Numbers and Terms Used

1	laser beam
2	focusing mirror
3	workpiece/floor slab
t	depth of the microcraters produced
a	distance of the microcraters from one another
d_w	diameter of the microcraters produced = work spot diameter
V_y	deflection speed of the laser beam
V_x	rate of feed of the floor slab / workpiece in x direction

Patent Claims

1. Non-slip floor covering, especially of mineral materials, characterized therein that the surface of the floor covering is additionally non-slip in that depressions in the form of microcraters with suction effect are regularly or randomly distributed over it.

2. Non-slip floor covering according to claim 1, characterized therein that the depressions in the form of microcraters with suction effect, which are regularly or randomly distributed, are as flat as possible.

3. Non-slip floor covering according to claim 1 or 2, characterized therein that the depressions are invisible to the human eye.

4. Non-slip floor covering according to one or more of the claims 1 to 3, characterized therein that the depressions are sharp-edged.

5. Non-slip floor covering according to one or more of th claims 1 to 4, characterized therein that the depressions exhibit a lenticular geometry.

6. Non-slip floor covering according to one or more of th claims 1 to 5, characterized therein that these depressions have a maximum lateral expansion of 0.4 mm and a depth of 0.01 - 0.2 mm.

7. Non-slip floor covering according to one or more of the claims 1 to 6, characterized therein that, in non-slip floor slabs, more than 100 depressions per cm^2 are arranged over their surface.

8. Non-slip floor covering according to claim 7, characterized therein that, in non-slip floor slabs made of granite, more than 250 depressions per cm^2 are arranged over their

surface.

9. Process for producing non-slip floor coverings, especially of mineral materials such as e.g. stone or granite or ceramic, according to one or more of the claims 1 to 8 by means of pulse laser bombardment, characterized therein that microcraters with suction effect, which are invisible to the human eye and regularly or randomly distributed, are produced on the surface of the floor covering by the laser pulses.

10. Process according to claim 9, characterized therein that the laser beam parameters, such as e.g. energy density, pulse duration etc., are selected in dependency on the material of the floor covering in such a way that the material removal for producing the microcraters essentially takes place by evaporation.

11. Process according to claim 10, characterized therein that, in the case of the treatment of highly polished surfaces of a floor covering made of natural stone, such as e.g. granite, the pulse energy is 0.4 mJ to 1.5 mJ, the pulse duration 50 ns to 250 ns, the work spot diameter 0.05 mm to 0.2 mm and the distance of the individual microcraters to one another 0.25 mm to 0.8 mm.

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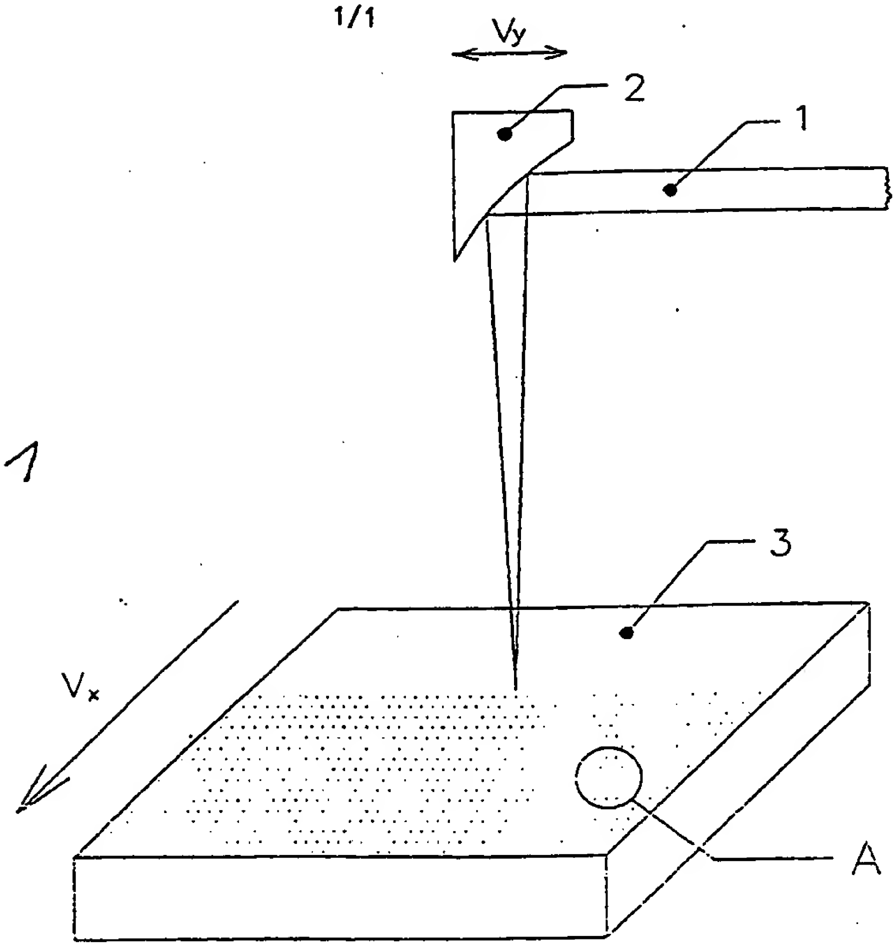

Fig. 1

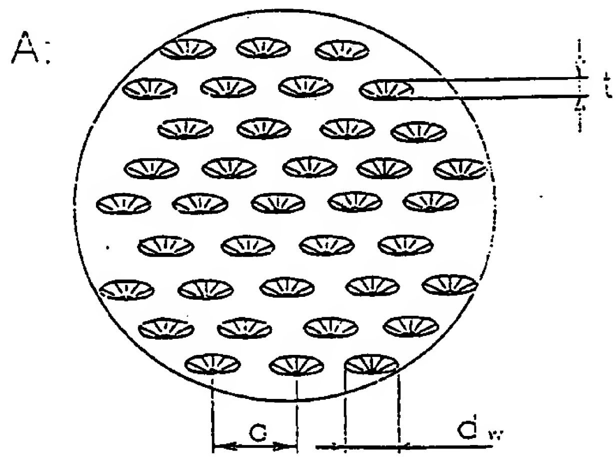

Fig. 2